Lawrence Berkeley Laboratory
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APPLIED SCIENCE DIVISION

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OFFICE WORKER RESPONSE TO LIGHTING AND DAYLIGHTING ISSUES IN WORKSPACE ENVIRONMENTS: A PILOT STUDY

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ABSTRACT

Based on a pilot survey of workers in an office building in St. Louis, Missouri, we evaluate reported levels of importance and satisfaction associated with lighting controls and other environmental conditions in workspaces and how they relate to physical features of the building and selected sociodemographic characteristics. We found that most respondents considered the majority of their workspace conditions important and satisfactory. The data suggest a negative relationship between how people evaluate the importance of and their satisfaction with their working environment: those who are least satisfied with features of their workspace consider these features very important, and vice versa. We also found that floor location, window orientation, and gender of worker were statistically significant correlates of many attitudes toward workspace features. Optimal benefits from new lighting and related control technologies will require good design and efficient hardware; however, our results suggest that careful integration of these technologies with worker values and priorities is essential if potential benefits are to be realized.

INTRODUCTION

Lighting typically consumes 30 to 50% of the energy used in commercial office buildings [1]. A significant amount of lighting energy can be reduced by incorporating new lighting hardware, controls, and operating strategies in the design of new and retrofitted facilities. For example, automatic exterior shading of sunlight and dimming of interior electric lights in response to available daylight offer energy savings as well as adequate lighting quantity and quality for most work tasks in perimeter zones. Until now, however, evaluations of such sophisticated systems have primarily emphasized technical and economic criteria (e.g., costs, benefits, and payback periods) without considering the effects of these new technologies on office workers.

The response of workers in office buildings to lighting control systems is an important area in need of study [2]. For example, unfamiliar or "unfriendly" controls may result in negative responses from affected workers, leading to possible misuse, alteration, or disuse of the controls. In order to ensure that potentially useful technologies are made "user-friendly," an understanding of worker response benefits are to be realized. This is particularly important in daylighted buildings where the proper integration of daylighting source controls (fenestration controls) and electric lighting systems is necessary for a successful design. With this awareness, architects and designers, building owners and managers, and office workers will be able to

participate in developing control strategies that will provide satisfactory conditions in office workspaces.

Recent research indicates that worker satisfaction with office environments is associated with job performance [2,3]. Among the physical environmental conditions considered important for worker satisfaction are acoustics, heating, ventilation (including air quality), air conditioning, lighting, outside view, and the design of the workspace.

Lighting is considered one of the most important features affecting worker satisfaction with the work environment, and was a feature rated satisfactory by most workers surveyed [2,4]. However, these studies focus on the visibility ratings of lighting for various tasks rather than on emerging control issues associated with new hardware and operating strategies.

Daylighting and view are also perceived as important factors affecting workspace satisfaction [2]. Research suggests that workers desire daylighting, independent of its contribution to task visibility. In most cases, control of daylight admission can regulate heat gain from sunlight and overcome glare to provide high-quality visibility for most office tasks.

The purpose of our research program on occupant response is to evaluate the level of worker satisfaction in office buildings that contain new lighting and fenestration controls. This pilot survey is a first step in developing approaches to measuring occupant response, although this building does not include sophisticated

control technologies. We analyzed worker-reported levels of importance and satisfaction associated with lighting controls and other environmental conditions in affected workspaces and how they are related to selected sociodemographic features (e.g., age, gender). In addition, we measured selected physical parameters (e.g., light, temperature, sound) and documented the physical features of representative workspaces with photographs. The findings presented in this paper represent the preliminary stage of an ongoing research project concerning workers' responses to lighting and related controls, and the effect of these responses on energy use in commercial buildings.

METHODOLOGY

During January 1983, we conducted our first survey in the recently renovated Wainwright office building in St. Louis, Missouri. This nine-story-high landmark structure was constructed in 1891, with office wings wrapping around three sides of an interior light well (atrium) (Fig. 1). High, exterior windows and narrow building sections allowed daylight to penetrate deep into the interior. In 1981, the structure was extensively renovated for occupancy by various state agencies. The light well is now enclosed by a glass skylight and a fourth (north) wall; the original windows, now bounding the interior circulation corridor, open onto a new atrium. Additional office space was provided by a new, three-story complex joined to the base of the Wainwright building.

A self-administered questionnaire for office workers was developed that emphasized lighting conditions and related features (e.g., thermal, acoustical, and human comfort conditions) typical of office workspaces.† The survey's 61 questions were organized into two groups: (1) attitudes about conditions of the workspace (the particular part of the office in which respondents do most of their work); and (2) background questions, such as location of the workspace (outside, middle, and interior of each floor); workspace plan (open, closed); amount of time spent with this organization and in the present workspace; and each worker's age and gender. Each respondent estimated the degree of importance and satisfaction associated with 24 features of his/her workspace (Table 2). Workers used a 4-point scale to respond to attitudinal statements (1 = most important or most satisfied; 4 = least important or least satisfied). In addition, they ranked the three most important and three least important features, as well as the three most satisfying and three least satisfying features. The 24 workspace features that we asked about are recognized in current literature as important lighting-related factors. They were presented to respondents in an order that reduced emphasis on the variables in which we were most interested (i.e., the questionnaire was structured to avoid response bias). At the end of the testing, respondents were invited to comment on conditions not included in the questionnaire.

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†A copy of the questionnaire is available from the authors.

Questionnaires were distributed to workers on all nine floors; locations included the exterior perimeter and interior of the building and areas adjacent to the interior circulation corridor, bordering the light well. Locations were marked on plan drawings and confirmed during collection of the questionnaires on the same day. Our sample size was 162 office workers; we achieved a 97% response rate.

After completing the survey, we took measurements of related physical conditions in representative workspaces:

- illuminance levels on work surfaces;
- luminance levels of ceiling light sources and surrounding surfaces;
- dry and wet bulb temperatures;
- background sound levels;
- physical dimensions of representative office furniture.

In addition, we photographed representative work stations for later analysis.

Lighting measurements included illuminance and luminance levels. General lighting was usually provided by ceiling-mounted fluorescent fixtures. Lighting levels differed in each location as a result of proximity to these ceiling fixtures. There were few task lights. Illuminance levels of work-surfaces ranged between 320 and 650 lux, averaging 550 lux. Luminance levels of lighting fixtures averaged 3000 cd/m^2; reflectance of surrounding surfaces averaged 82% for white gypsum-board wall surfaces, 32% for gray, fabric-covered furniture, and 14% for darker gray

carpeting.

Thermal measurements included dry and wet bulb temperatures. Average dry bulb temperature was 26°C, and average wet bulb temperature was 14°C, providing 20% relative humidity.

Background sound levels were dominated by sounds broadcasted from loudspeakers located above the hung ceilings. Background sound level measurements ranged between 44 and 57 dBA, averaging 52 dBA. Noise levels of office equipment were not evaluated.

RESULTS

We present our initial findings in four sections. First, we briefly describe the sample of office workers surveyed. In the second section, we report the degree of importance and satisfaction they associated with specific features of their workspaces. In the third section, we use factor analysis to investigate the commonality of and interrelationships among the work area features. In the fourth section, we analyze correlates of attitudes toward the working environment.

All statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) [5] through the computer center at Lawrence Berkeley Laboratory.

Sample description

Almost 80% of the 162 workers surveyed were women (Table 1). Approximately one-half of the workers were between 30 and 39 years old; more than three-quarters were between 20 and 49 years old. About 70% of those sampled had worked in the same workspace for 1 year or more. Most respondents were located along the exterior periphery of the building (51%), and most occupied open-plan workspaces (88%). Due to the absence of similar data on the entire population of office workers in this building, we were unable to evaluate quantitatively the representativeness of our sample. However, based on impressionistic data, we conclude that the sample was reasonably representative of the building population.

Importance of and satisfaction with workspace features

We first asked office workers to rate the importance of 24 features of their workspace as those features relate to the workers' well-being ("... show how important it is to you for that feature to be satisfactory"). We then asked them to rate their satisfaction with these same features ("... show how satisfied you are with that feature in your own work station"). These features, listed in the same order as in the questionnaire, appear in Table 2. The ratings are shown in Table 3. Column 1 lists the features of the workspace. Columns 2 through 5 list the percentages of responses in terms of importance (light band) and satisfaction (shaded band). The percentages are based on the proportion of the total sample for which each workspace feature was applicable.

More than 90% of the respondents indicated that the amount and quality of light for reading and writing were very important, while more than 75% believed the amount of space in their areas and the comfort of their chairs were very important. Also, more than 50% of the individuals reported that the arrangement of their desks, bookcases, and other furniture, and the freedom to have private conversations and private telephone discussions in their work areas were very important to them. Moreover, the amount and quality of light for computing, filing, and other tasks, and the means to control glare from lighting sources, were considered very important by most respondents. The means to control the temperature and ventilation in their work areas during summer and winter were very important to more than 60% of respondents. Moreover, few people thought that these weather-dependent variables were unimportant. In fact, most workers said most workspace features were important (privacy of work area was the only exception).

Those features deemed to be not too important or not important at all by at least 20% of the sample were: privacy of work area; the kind of view from a window; the ability to control sound from outside the building or from other places within the building; and access to controls for work-surface lighting, ceiling lighting, venetian blinds, drapes, and other lights.

In order to discover how important each feature was in relation to the other characteristics of the workspace, we asked each person to rank the most important and least important features. Each respondent listed three features (out of a possible 24) in

order of importance. The three highest percentages are listed in the light band (top half of each numbered row) of Columns 7 through 12 in Table 3. The proper amount of space, the ability to control summer temperatures, and the ability to have private phone discussions were ranked among the three most important features of the workspace. The ability to have private office conversations, the correct amount of light for reading, and the control of summer and winter ventilation were also ranked among the most important features. Window views, the control of noise outside the building, and the privacy of work area were rated among the three least important features. The control of drapes and access to controls of other lights were also considered to be of very little importance.

We next examined how satisfied each individual was with respect to each of the workspace features described above (the shaded band in Columns 2 through 4 in Table 3). The most interesting difference between these results and those regarding importance was the extent of dissatisfaction with some of the workspace features. For example, a majority of workers were very satisfied with only two workspace features--the control of noise from outside the building (64%) and the control of venetian blinds (62%). There was a great deal of dissatisfaction (averaging 60%) with the control of winter and summer temperatures and some dissatisfaction (averaging 40%) with the control of winter and summer ventilation. Moreover, more than one-third of the respondents were dissatisfied with a number of characteristics of their working environment: privacy of work area, conversational privacy, and

access to work-surface lighting controls.

Nevertheless, most office workers were satisfied with many features of their workspaces: the amount of space and arrangement of the furniture; the comfort of their chairs; privacy of work areas; view from their windows; control of sounds within the building; control of glare; the amount and quality of light for reading, writing, computing, filing, and other tasks; and access to control of lights and shading devices.

In order to see how satisfaction with one feature of the workspace compared with satisfaction with other characteristics, we asked each person to rank three features as being most satisfying and three as least satisfying to them. The three highest percentages are listed in the shaded band (bottom half of each numbered row) of Columns 7 through 12 in Table 3. Respondents were most satisfied with the sizes of their workspaces, the amount and quality of light for reading, and the comfort of their chairs. They were also very satisfied with the way their desks, bookcases, and other furniture were arranged and the means to control sounds from outside the building.

Respondents were least satisfied with the ability to control winter and summer temperatures and the means to have private phone discussions. They were also dissatisfied with the possibilities for having private office discussions and with the control of summer ventilation.

We next examined the correlations† between reported importance and satisfaction for each workspace feature (Column 6 in Table 3). The results indicate a negative relationship (statistically significant)‡ between how an individual evaluated the importance of a particular feature of his/her working environment and his/her satisfaction with it. For example, workers who were least satisfied with the control of summer and winter temperatures and ventilation considered these features very important. On the other hand, workers who were most satisfied with these features considered them unimportant.

A more graphic summary of the relationship between the importance of and the satisfaction with workspace features is presented in Fig. 2. The data points represent the 24 variables. The coordinates of these variables represent the average responses of the total sample of office workers (where 1 was recorded as least important or least satisfactory and 4 as most important or most satisfactory).

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†In correlation analysis, the correlation coefficient is a measure of the degree of relationship present between two linearly related variables. In a perfect positive relationship between two variables, the correlation coefficient is equal to 1.00. In a perfect negative relationship, the correlation coefficient is equal to -1.00. If there is no relationship between the two variables, the correlation coefficient is 0. See Ref. [6] for more information on correlation analysis.

‡In determining statistical significance in this study, 90% and 95% levels of significance are used in measuring the association between variables. A 95% level of significance indicates that there is a 5/100 chance that associations are not statistically significant but are simply the result of sampling error or random effects (i.e., we are 95% confident that the measured associations are statistically significant in the population). See Ref. [7] for more information on statistical significance.

As seen in Fig. 2, those features deemed by the entire sample to be most important and most satisfactory were the amount and quality of light for reading, writing, and other tasks; the amount of space; and the comfort of chairs. The most dissatisfaction occurred for two of the most important workspace features: the control of summer and of winter temperatures. The correlation between the mean values of importance and satisfaction for all workspace features was -0.15, a negative but not statistically significant relationship. Examination of Fig. 2 suggests that there is a substantial subset of features for which the correlation between importance and satisfaction can be viewed as positive. More detailed analysis, including additional building studies, is required to better understand these results.

Attitudinal factors

Another objective of this project was to discover how questions concerning importance were related to one another, how questions concerning satisfaction were related to each other, and how both sets of questions were related to one another. By examining correlation matrices and conducting factor analysis, we

discovered distinct groups of variables, called factors.†

The 24 attitudinal questions on importance of workspace features were subjected to principal factor analysis.‡ The factors are listed in Table 4 in order of importance, the first factor being the one that accounts for the most variance and, therefore, the most important factor. There are eight primary factors: thermal controls, lighting controls, light for specialized tasks, sound controls, privacy, light for general tasks, shading devices, and office design.

The first factor (thermal controls) consisted of variables related to temperature and ventilation. The second factor (lighting controls) contained variables concerning access to controls for work-surface lighting and ceiling lighting. The third factor (light for specialized tasks) concerned the amount and quality of light for computing, filing, and other tasks. The fourth factor

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†Factor analysis is a method for reducing a large number of variables to a smaller number of presumed underlying unities termed factors. Factors are hypothetical variables derived from the intercorrelations among variables. Although the generation of factors by no means insures meaning, the factors that were produced in this project are regarded as meaningful by the authors. The factors used in the analysis were based on the clustering of factor loadings that were simply the correlations between each variable and each factor. Varimax rotation was used to simplify the interpretation of factors; this statistical method leads to a relatively small number of variables having high loadings on one factor and the rest of the variables having no loadings on it. See Refs. [8] and [9] for more information on factor analysis.

‡Eight factors were extracted having eigenvalues greater than 1. The factors were varimax rotated; variables that had loadings of 0.75 or greater on a rotated factor were examined. These factors explained 75% of the total variance of the attitudinal variables. The first three factors explained almost 44% of the total variance of the attitudinal factors.

(sound controls) contained two variables that concerned the control of sounds from outside the building and from other places within the building. The fifth factor (privacy) represented variables concerning the privacy available for discussions on the telephone or in the office. The sixth factor (light for general tasks) consisted of variables related to the amount and quality of light for everyday tasks (reading and writing). The seventh factor (shading devices) contained variables relating to the control of drapes and venetian blinds. The eighth and final factor (office design) was composed of only one variable: the amount of space in the office. In general, these factors made inherently good sense and were logically consistent. In future analyses, we hope to make use of these eight factors (or a subset of these factors) for examining lighting controls and energy use in office buildings.

We next subjected the 24 attitudinal questions on satisfaction with workspace features to principal factor analysis, using the methodology described above.† The groupings of satisfaction variables were found to be similar to those for importance variables (Table 5). Despite minor variations in the ordering of the factors and in the groupings within the factors, the two sets of factors were extremely consistent. Thus, the data indicate subgroups of workspace features of similar importance and/or satisfaction.

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†Six factors were extracted having eigenvalues greater than 1. These factors explained 76% of the total variance of the attitudinal variables. The first two factors explained almost 52% of the total variance of the attitudinal factors.

We then subjected all 48 attitudinal questions concerning workspace features to principal factor analysis. The constructed factors were no different than factors previously extracted in the separate analyses of importance and satisfaction variables.

The purpose of the factor analysis was heuristic: we wished to isolate reasonable attitudinal dimensions that reflect respondents' basic conceptualizations of their working environment. We note, however, that this conceptualization is constrained by the topics addressed in the questionnaire. In future work, we hope to relate these and other are attitudinal factors to specific lighting controls and actual energy consumption.

Correlates of attitudes

Another objective of this investigation was to analyze correlates of attitudes toward workspace conditions. We analyzed correlations among the perceived importance of and satisfaction with workspace features and the following variables: floor level; location of workspace (outside, middle, or interior); plan of workspace (open or closed); orientation of proximate windows (north, east, south, or west); tenancy (amount of time spent at workspace); and each worker's age and gender (Columns 13 through 19 in Table 3). The correlations for importance and satisfaction are listed in the light and shaded bands, respectively, of Columns 13 through 19. We examined the statistical significance of the correlations at both the 0.05 and 0.01 levels. The following discussion interprets only those variables that were statistically significant at these levels.

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It is important to note that this analysis concerns only those questions asked in the questionnaire. Therefore, it is possible that data not collected in this study (on characteristics such as job responsibilities, work activities, salary, and seniority) may be important correlates of attitudes toward workspace conditions. We hope to include such questions in future studies.

Floor level was statistically correlated with 2 importance and 14 satisfaction variables (Table 3, Column 13). Workers at higher floor levels believed private phone and office discussions were more important than did individuals at lower floor levels. Moreover, office workers at the higher levels were less satisfied with many workspace features, such as control of summer and winter ventilation; amount and quality of light for computing, filing, and other tasks; and access to controls for work-surface lighting, ceiling lighting, and other lights.

Workspace location—outside, middle, or interior—was statistically correlated with 6 importance and 4 satisfaction variables (Table 3, Column 14). For example, access to the controls of work-surface lighting and venetian blinds was more important to workers located in workspaces along the exterior of the building (outside workspaces) than to workers in middle and interior workspaces. On the other hand, the amount and quality of light for filing and for other tasks was more important for workers in interior workspaces than for workers elsewhere. Workers in outside spaces were more satisfied than other workers with the comfort of their chairs, with their window views, and with the

control of venetian blinds and drapes.

Orientation of windows in the workspace was statistically correlated with 4 importance and 4 satisfaction variables (Table 3, Column 15). Workers having windows facing north found views and the control of venetian blinds more important than did workers whose windows faced other directions (especially, those oriented to the west). Light for computing and for filing was less important to workers having north-facing windows than to others. On the other hand, workers having north-facing windows found the control of work-surface lighting, ceiling lighting, and inside sound to be least satisfactory while they were satisfied with their privacy for office conversations.

Workspace plan--open or closed--was statistically correlated with 6 importance and 7 satisfaction variables (Table 3, Column 16). Workers in closed-plan workspaces indicated, for example, that access to control of ceiling lighting, venetian blinds, drapes, and other lights was more important than did workers in open-plan workspaces. Those in open workspaces were less satisfied with a number of workspace features, such as access to the control of work-surface lighting, than were workers in closed-plan workspaces.

Tenancy, or the amount of time spent in the same work space, was statistically correlated with 7 importance and 3 satisfaction variables (Table 3, Column 17). We examined three categories of workers: individuals who had been at the same workspace for 6 months or less, for more than 6 months but less than 1 year, or

for more than 1 year (see Table 1). We found that the longer people worked in the same workspace the more importance they attached to the arrangement of furniture, the privacy of the work area, the kind of view from their windows, the amount of workspace, and telephone and office conversational privacy. In contrast, more recent arrivals perceived the control of winter ventilation to be more important than did longer-term workers. Also, the longer people worked in the same workspace, the less they were satisfied with window view, control of summer ventilation, and control of sounds from outside the building.

Gender was statistically correlated with 12 importance and 5 satisfaction variables (Table 3, Column 18). Women found, for example, the control of summer and winter temperatures and ventilation and the amount and quality of light for filing, computing, and other tasks to be more important than did men. On the other hand, men found control of both outside and inside sounds, privacy for office discussions, and access to control of venetian blinds more important than did women. In terms of satisfaction, women were less satisfied than men with the amount of workspace, the control of glare, the control of summer and winter temperatures, and their access to control of work-surface lighting.

Age was negatively correlated with 2 importance and 7 satisfaction variables (Table 3, Column 19). Younger respondents, for example, considered the amount of space and the kind of view from a window to be more important than did older office workers. Moreover, younger workers were less satisfied than older workers with

a number of workspace features such as window views and the amount and quality of light for writing and computing.

In summary, there was a strong relationship between peoples' physical location in the building and their perceived importance of and satisfaction with certain lighting controls and other workspace conditions. Location within a building—at a particular floor level or workspace—was significantly correlated with a number of features. As stated previously, however, other features (e.g., job responsibilities, etc.) may be underlying determinants of workers' attitudes toward their work environments. Gender and age were also important correlates of perceived importance of and satisfaction with workspace conditions: women and younger office workers were less satisfied with many features of their work environments.

SUMMARY

Most respondents in our sample considered the majority of their workspace conditions important. This confirms our working hypothesis that the conditions we studied are important to workers. However, we realize that there may be other conditions not included in our questionnaire that may affect worker response to emerging lighting and related control technologies.

It was interesting to find that at least 20% of those surveyed believed that access to controls for work-surface lighting, ceiling lighting, venetian blinds, drapes, and other lights were not very important or not important at all. A possible reason is that

window controls in this building are limited to venetian blinds that are seldom used for light, thermal, or view control. Moreover, the limited views from the windows may strongly influence peoples' use of the blinds: there are high-rise buildings to the north and south, mid-rise parking facilities to the east, and older, low-rise structures to the west. Thus is possible that workers regard view and lighting-related controls as more important when views are more pleasing and, more importantly, when lighting controls are automatic.

Most workers in this facility were satisfied with the conditions of their work environments. However, there was considerable dissatisfaction with the control of summer and winter temperatures and ventilation. We found this dissatisfaction justified on the basis of the physical measurements conducted in the building during the winter--many areas were overheated. We intend to conduct a similar survey during the summer in this building to determine whether workers' dissatisfaction is also justified during the cooling season.

One of the more important findings at this stage in the project was the negative relationship between how individuals evaluate the importance of and their satisfaction with their working environment. It appears that those who are least satisfied with features of their workspaces consider these features to be very important. Similarly, those who are most satisfied with certain conditions consider them to be unimportant.

We also found that workspace conditions are complex and interrelated. Most workspace features can be categorized into groups (factors): thermal controls, lighting controls, sound controls, and shading devices. One consequence of this finding is understanding that changing one feature is likely to alter other, interrelated features of the workspace. Consequently, attempts to improve one workspace condition may improve other conditions. For example, providing control over winter temperatures might also enable workers to control summer temperatures.

Evaluations of importance of and satisfaction with workspace features were affected by location in the building (floor level and proximity to exterior or interior), workspace plan (open or closed), window orientation, amount of time spent at workspace, and the age and gender of the respondents. In particular, we found that floor location, window orientation, and gender were correlates of many attitudes toward workspace features. Consequently, optimal benefits from new lighting and related control technologies will depend on careful integration with worker values and priorities. Assuming that all workers would respond similarly to these technologies would probably lead to the problems mentioned at the beginning of this paper—misuse, alteration, or disuse of control technologies—along with related problems of lighting energy waste and deterioration in workers' satisfaction and performance.

Because this project was one of the first to analyze office worker response to lighting controls and other environmental conditions, we believe that improvements can be made in the types of questions included in the survey. Additional questions should be asked about office workers' roles and positions within their organization: for example, their job responsibilities, seniority, salary, and work tasks. Answers to these questions would act as controls in analyzing the correlates of attitudes. Some of the questions themselves could be made more specific for comparative purposes, for example, by including actual temperature ranges for estimating satisfaction with winter and summer temperatures.

Caution should be used when generalizing from this study to other buildings and regions. It is possible that our results are unique and not representative of other office buildings and areas around the country. Similar studies in other buildings, in other regions, and with other population samples are necessary before we can conclusively describe the attitudes and behavior of office workers toward workspace environments.

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Table 1 Characteristics of office workers in the Wainwright building.

		Percent (%)
Gender		
	Male	20.9
	Female	79.1
Age		
	Less than 20 years	0.6
	20 - 29 years	22.8
	30 - 39 years	42.4
	40 - 49 years	13.3
	50 - 59 years	15.2
	60 - 69 years	5.1
	70 years or older	0.6
Workspace tenancy		
	6 months or less	13.9
	6 months - 1 year	19.2
	1 year or more	66.9
Location of workspace		
	Outside	50.6
	Middle	26.5
	Interior	22.8
Orientation of workspace		
	North	9.9
	East	29.0
	South	29.0
	West	32.1
Plan of workspace		
	Open	88.3
	Closed	11.7

Table 2 Workspace features.

Workspace feature	Description
Amount of space	Amount of space in workspace
Furniture arrangement	Arrangement of desk, bookcases, and other furniture
Chair comfort	Comfort of chair
Privacy of work area	Visual access or privacy of work area
View from window	Kind of view from window
Control of outside sound	Ability to control sound from outside the building
Control of inside sound	Ability to control sound from other places within the building
Control of glare	Control of glare from light sources
Private phone talks	Ability to have private telephone discussions
Private office talks	Ability to have private conversations in work area
Control of summer temperatures	Ability to control the temperature in work area during summer months
Control of winter temperatures	Ability to control the temperature in work area during winter months
Control of summer ventilation	Ability to control ventilation in work area during summer months
Control of winter ventilation	Ability to control ventilation in work area during winter months
Light for reading	The right amount and quality of light for reading
Light for writing	The right amount and quality of light for writing
Light for computing	The right amount and quality of light for computing
Light for filing	The right amount and quality of light for filing
Light for other tasks	The right amount and quality of light for other tasks
Control of work-surface lighting	Access to controls for work-surface lighting
Control of ceiling lighting	Access to controls for ceiling lighting
Control of venetian blinds	Access to controls for venetian blinds
Control of drapes	Access to controls for drapes
Control of other lights	Access to controls for other lights

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
						Most Important Most Satisfied			Least Important Least Satisfied			Correlation						
Workspace Condition	Very Important Very Satisfied (%)	Somewhat Important Somewhat Satisfied (%)	Not Too Important Not Too Satisfied (%)	Not at All Important Not at All Satisfied (%)	Correlation	First (%)	Second (%)	Third (%)	First (%)	Second (%)	Third (%)	Office Floor Level	Office Location	Window Orientation	Office Plan	Worker Tenancy	Worker Gender	Worker Age
1. Amount of space	78.3 **86.4**	19.9 **37.8**	1.2 **16.7**	0.6 **9.5**	-0.13**	27.0 **39.0**		7.0				**0.16***			**-0.22***	-0.14** **0.17****		-0.14**
2. Furniture arrangement	56.8 **84.2**	37.0 **48.8**	5.6 **14.9**	0.6 **8.8**	-0.13**		12.0					**0.14****			**-0.19***	-0.18*	-0.13** **-0.16****	
3. Chair comfort	78.4 **41.4**	21.1 **57.9**	2.5 **16.8**	0 **8.8**	-0.14**	**11.8**		**10.8**					**0.13****					**-0.29***
4. Privacy of work area	22.6 **87.8**	24.5 **84.8**	32.1 **84.8**	20.8 **13.7**	-0.29*				12.0			**0.22***			**-0.15****	-0.20*		**-0.17****
5. View from window	26.2 **86.4**	37.9 **36.8**	24.8 **10.8**	11.0 **17.4**	-0.10				24.0	10.0			**0.29***	0.11**		-0.31* **0.20***		0.16** **-0.19****
6. Control of outside sound	31.8 **84.8**	31.8 **84.8**	23.6 **1.4**	12.8 **0**	-0.13		**12.0**	**10.0**	19.0	20.0	9.0					**0.18****	0.14**	
7. Control of inside sound	45.3 **84.0**	32.0 **37.8**	18.7 **19.2**	4.0 **0.0**	-0.30*							**0.22***		**-0.14****	**-0.20***		0.22*	
8. Control of lighting glare	56.8 **86.6**	35.5 **41.0**	6.5 **14.1**	1.3 **8.4**	-0.21*												**0.13****	
9. Private phone talks	61.9 **26.3**	23.8 **30.0**	11.2 **27.0**	3.1 **16.4**	-0.25*	11.0			**13.0**	**18.0**		-0.23* **0.27***	0.31*		-0.16** **-0.24***	-0.17**		
10. Private office talks	62.7 **86.9**	26.6 **22.5**	8.9 **34.4**	1.9 **16.2**	-0.20*		11.0	10.0			**18.0**	-0.20* **0.23***	0.38*	**0.11****	-0.17* **-0.30***	-0.15**	0.16**	
11. Control of summer temperatures	66.5 **10.1**	29.7 **29.7**	3.9 **40.5**	0 **19.8**	-0.31*	11.0	15.0		**16.0**	**30.0**							-0.15** **0.15****	
12. Control of winter temperatures	71.4 **8.1**	27.3 **28.1**	1.3 **40.6**	0 **23.1**	-0.34*				**13.0**	**15.0**	**14.0**						-0.22* **0.13****	**-0.15****

*Significant at the 0.01 level
**Significant at the 0.05 level

XBL 844-1523

Table 3. Statistical measures of the importance of and satisfaction with workspace features.* Continued on next page.

*The percentages and correlations are based on the proportion of the total sample for which each workspace feature is applicable.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
						Most Important Most Satisfied			Least Important Least Satisfied			Correlation						
Workspace Condition	Very Important Very Satisfied (%)	Somewhat Important Somewhat Satisfied (%)	Not Too Important Not Too Satisfied (%)	Not at All Important Not at All Satisfied (%)	Correlation	First (%)	Second (%)	Third (%)	First (%)	Second (%)	Third (%)	Office Floor Level	Office Location	Window Orientation	Office Plan	Worker Tenancy	Worker Gender	Worker Age
13. Control of summer ventilation	62.3 13.9	33.8 42.4	3.9 39.7	0 13.9	-0.31**			11.0			11.8	0.17**				0.16*	-0.18*	
14. Control of winter ventilation	60.3 13.9	35.1 47.8	4.6 25.8	0 13.9	-0.34**			11.0				0.14**				0.14**	-0.16**	
15. Light for reading	94.4 44.1	5.0 36.4	0.6 13.7	0 5.8	-0.06	14.8	10.0 11.8											
16. Light for writing	91.2 44.1	8.1 36.8	0.6 13.7	0 5.8	-0.05													-0.19**
17. Light for computing	62.1 37.8	22.7 46.1	12.1 9.8	3.0 6.8	0.13							0.39*		-0.17**			-0.35*	-0.27**
18. Light for filing	83.8 46.4	17.8 41.7	13.1 7.4	5.6 5.6	0.07							0.19**	-0.17**	-0.16**			-0.29*	
19. Light for other tasks	89.0 39.8	26.9 49.8	2.8 6.8	1.4 4.1	0.07							0.19**	-0.16**				-0.24*	
20. Control of work surface lighting	49.6 31.7	24.1 29.2	21.3 23.3	5.0 15.8	-0.22*							0.19**	0.17**	-0.13**	-0.22*		0.17**	
21. Control of ceiling lighting	36.3 82.8	30.8 35.8	26.7 17.8	6.2 14.8	-0.06							0.21*		-0.18**	-0.23*			
22. Control of venetian blinds	42.1 62.8	36.4 31.8	14.3 5.1	7.1 5.1	0.18**								0.31* 0.23*	0.13*	-0.15**		0.14**	
23. Control of drapes	35.1 46.8	28.6 43.6	20.8 5.1	15.6 5.1	0.19					11.0	9.0		0.28**		-0.24**			
24. Control of other lights	28.3 24.4	28.3 46.8	31.7 18.8	11.7 10.8	-0.11						16.0	0.18**			-0.15**			

*Significant at the 0.01 level.
**Significant at the 0.05 level.

XBL 844-1524

Table 3, continued.

Table 4 Factor analysis of importance of workspace features.*

Factor 1:	Thermal controls	
	Control of winter ventilation	0.88
	Control of summer ventilation	0.88
	Control of winter temperatures	0.80
	Control of summer temperatures	0.78
Factor 2:	Lighting controls	
	Control of work-surface lighting	0.88
	Control of ceiling lighting	0.86
Factor 3:	Light for specialized tasks	
	Light for computing	0.94
	Light for other tasks	0.86
	Light for filing	0.80
Factor 4:	Sound controls	
	Control of inside sound	0.89
	Control of outside sound	0.86
Factor 5:	Privacy	
	Private office talks	0.89
	Private phone talks	0.88
Factor 6:	Light for general tasks	
	Light for reading	0.92
	Light for writing	0.88
Factor 7:	Shading devices	
	Control of drapes	0.79
	Control of venetian blinds	0.76
Factor 8:	Office design	
	Amount of space	0.79

*Results are based on a varimax rotated factor matrix. The numbers represent the loadings (correlations) of each variable on each factor.

Table 5 Factor analysis of satisfaction with workspace features.*

Factor 1:	Lighting	
	Light for writing	0.92
	Light for reading	0.90
	Light for filing	0.83
	Light for other tasks	0.81
	Control of work-surface lighting	0.81
	Control of ceiling lighting	0.81
	Light for computing	0.80
Factor 2:	Thermal controls	
	Control of summer ventilation	0.88
	Control of winter ventilation	0.88
	Control of summer temperatures	0.83
	Control of winter temperatures	0.80
Factor 3:	Privacy	
	Private phone talks	0.80
	Private office talks	0.79
Factor 4:	Shading devices	
	Control of venetian blinds	0.90
	Control of drapes	0.88
Factor 5:	Office design	
	Amount of space	0.82
	Furniture arrangement	0.82
Factor 6:	Sound control	
	Control of outside sound	0.88

*Results are based on a varimax rotated factor matrix. The numbers represent the loadings (correlations) of each variable on each factor.

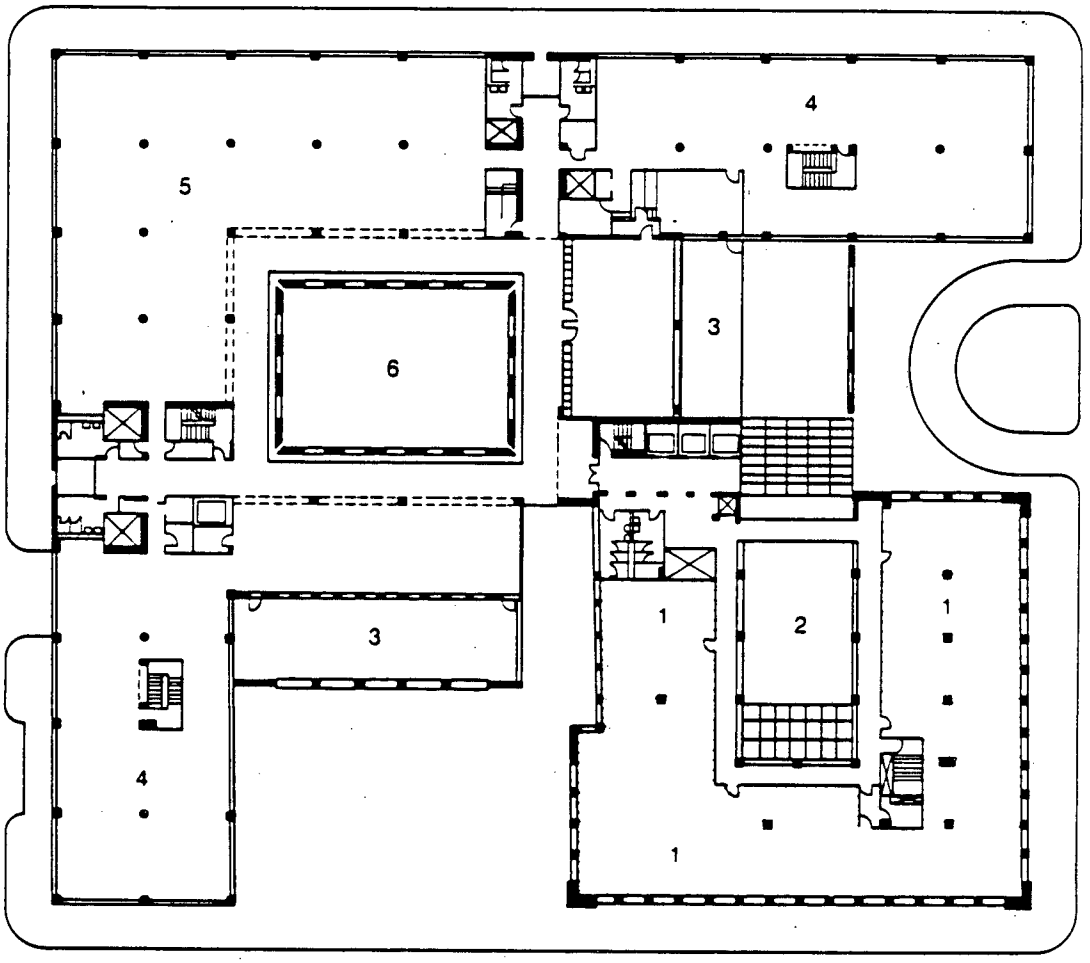
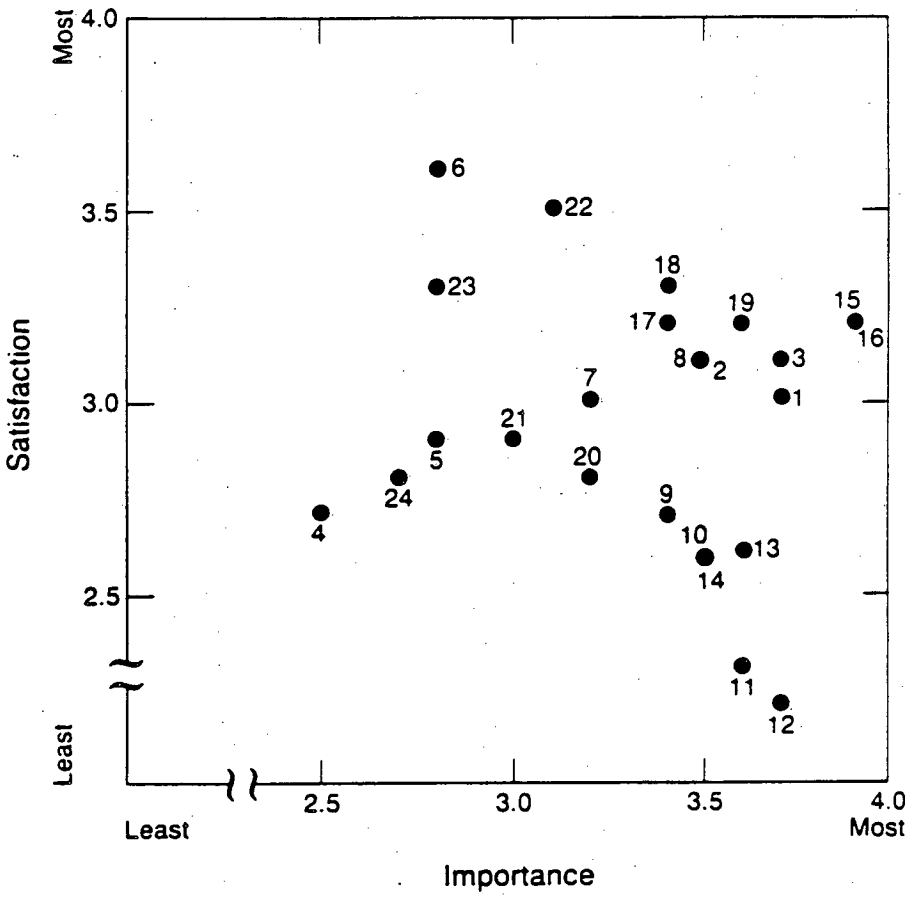


Figure 1: Floor plan of the Wainwright building. The sample was taken from workspaces in the shaded area.



1. Amount of space
2. Furniture arrangement
3. Chair comfort
4. Privacy of work area
5. View from window
6. Control of outside sound
7. Control of inside sound
8. Control of lighting glare
9. Private phone conversations
10. Private office conversations
11. Control of summer temperatures
12. Control of winter temperatures
13. Control of summer ventilation
14. Control of winter ventilation
15. Light for reading
16. Light for writing
17. Light for computing
18. Light for filing
19. Light for other tasks
20. Control of work surface lighting
21. Control of ceiling lighting
22. Control of venetian blinds
23. Control of drapes
24. Control of other lights

XBL 843-8372

Figure 2: Comparison of the importance of and satisfaction with workspace features.*

*Mean responses for the total sample are plotted and are based on the proportion of the total sample for which each workspace feature is applicable.

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